



NAVAL RESEARCH ADVISORY COMMITTEE

Science and Technology for Naval Warfare, 2015--2020

**Flag Officers
And
Senior Executive Service**

**4 October 2005
The Pentagon Auditorium**

| Report Documentation Page | | | | Form Approved OMB No. 0704-0188 | |
|--|------------------------------------|-------------------------------------|--|--|---------------------------------|
| Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. | | | | | |
| 1. REPORT DATE 04 OCT 2005 | | 2. REPORT TYPE N/A | | 3. DATES COVERED - | |
| 4. TITLE AND SUBTITLE Science and Technology For Naval Warfare, 2015-2020 | | | | 5a. CONTRACT NUMBER | |
| | | | | 5b. GRANT NUMBER | |
| | | | | 5c. PROGRAM ELEMENT NUMBER | |
| 6. AUTHOR(S) | | | | 5d. PROJECT NUMBER | |
| | | | | 5e. TASK NUMBER | |
| | | | | 5f. WORK UNIT NUMBER | |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Research Advisory Committee 800 North Quincy Street Arlington, VA 22217-5660 | | | | 8. PERFORMING ORGANIZATION REPORT NUMBER | |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) | | | | 10. SPONSOR/MONITOR'S ACRONYM(S) | |
| | | | | 11. SPONSOR/MONITOR'S REPORT NUMBER(S) | |
| 12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited | | | | | |
| 13. SUPPLEMENTARY NOTES The original document contains color images. | | | | | |
| 14. ABSTRACT | | | | | |
| 15. SUBJECT TERMS | | | | | |
| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT SAR | 18. NUMBER OF PAGES 34 | 19a. NAME OF RESPONSIBLE PERSON |
| a. REPORT unclassified | b. ABSTRACT unclassified | c. THIS PAGE unclassified | | | |



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Overarching Issues Requirements

Conclusion

Recommendations



Study Terms of Reference/1

Identify the science and technology in which the U.S. naval forces should consider investing to counter predicted threats and to enhance the effectiveness of U.S. naval forces in the period 2015 to 2020 while undertaking Littoral Operations.

Sponsor: Deputy Chief of Naval Operations
(Warfare Requirements and Programs) N6/7

Duration: Five Months



Terms of Reference/2

This study initially sought to identify the threat implications for three specific areas of the world; however, the issues appear to be universal because of the proliferation of weapons and systems that could threaten U.S. naval forces.

Although the geographic features of the three areas differ, the military implications for all areas appear to be similar.



Panel Membership

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Consultant

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Center for Naval Analyses

NRAC Staff

Cortana Corp.

APL, Johns Hopkins University

University of Texas at Austin

BearingPoint Inc.

Panel Secretary

KEITH H. THOMS

NSWC Dahlgren Labs

* Member, Naval Research Advisory Committee



Briefings and Discussions

Individuals

Dr. George H. Atkinson, S&T Advisor to the Secretary of State

Dr. Alan Berman, former Technical Director, NRL

Ambassador Linton Brooks, Under Secretary of Energy

Dr. Christopher Bowie, Dep. Director, Air Force Long-Range Planning

Dr. Richard Carlin, Former Acting Chief Scientist, ONR

Tom Clancy, novelist

RADM Richard Cobbold, RN (Ret), Director, RUSI

RADM Jay Cohen, USN, Director of Naval Research

VADM James Fitzgerald, USN (Ret)

LGEM James N. Mattis, USMC, CG, Marine Corps Combat Development
Command



Briefings and Discussions

Individuals (continued)

RADM William C. Miller, USN(Ret), Academic Dean, USNA

Dr. David A. Rosenberg, Director, Task Force History

CAPT Gordon Wilson, RN, former Director, Defence Studies (Naval)

Industry

Dr. Eric Horvitz, senior staff, Microsoft

George Pickett, Northrop Grumman

Dr. Scott Truver, Vice President, CSSO/Anteon



Briefings and Discussions

U.S. Government

Assessment Branch/OPNAV N81

Commander, Fleet ASW Command

Commander, Naval Special Warfare Command

Commander, Naval Surface Forces

Deep Red /OPNAV N2

DARPA (UAVs/Mechanical Bugs)

Office of Naval Intelligence (threat briefs, submarine technology)

ONR (UAVs, HI-FLY, non-acoustic ASW)

ONR Global/London (advanced air-defense concepts)

SPAWAR Systems Center (San Diego)

Strategic Studies Group (Naval War College)



Briefings and Discussions

British Government

Director of Intelligence (Maritime Systems)

Director General (Research & Technology)

Defense Science and Technology Laboratory

- Advanced radars
- Surface combatants/warfare
- Seabasing
- Electronic warfare
- Target identification
- Biological detection
- Littoral warfare
- ASW



Global S&T Trends/1

- Continued asymmetric opposition to U.S. interests
 - Non-state actors
 - Nation states
 - Military actions
 - Against U.S. critical infrastructure
 - Against U.S. civilian population
- Continued dilution of U.S. S&T base
 - Foreign students outnumber Americans in advanced engineering and science curricula
 - Technical education losing to business, arts
 - Government laboratory positions less attractive
 - Foreign investment in technical education accelerating



Global S&T Trends/2

- Globalization eroding U.S. technical dominance
- Impending oil availability crisis
 - U.S. dependence on Middle East oil
 - Near-term Chinese demand for oil
 - Mid-term EU, Indian demand for oil
 - Changing situation in Venezuela
- Increasing U.S. dependence on foreign technology
- Worldwide access to advanced technology through foreign and U.S. sales and espionage
- Technological surprise is **probable!**



Military Implications of the World of 2020 for S&T /1

This study makes no attempt to define the future or to draw possible scenarios for what the world will look like in 2015-2020. However, certain trends are obvious:

- Nuclear, chemical, bio weapons continue to proliferate
- Terrorism continues
- Increasing violence and political influence by non-state actors
- Proliferation of primitive (but effective) as well as modern weapons/systems
 - Improvised explosive devices
 - Man-portable air-defense missiles
 - Sea mines
 - Surface-to-surface missiles



Military Implications of the World of 2020 for S&T/2

- Growing foreign economic power and changing politics
 - Rapidly changing demographics
 - Major emphasis on advanced S&T education
 - Advanced weapon development and sales
- Development of significant regional military powers
 - Blue water navies: China, India
 - Regional navies: Iran



Navy-Marine Corps Missions in 2020

Many missions are similar to the Cold War era
BUT with significantly different emphasis

- ↑ Provide seaborne missile defense
- ↑ Provide seaborne support for operations against terrorism (including homeland defense)
- ↑ Protect U.S.-Allied maritime areas of interest (inc. SLOCs)
- ↑ Project military power (presence/rescue/peacekeeping/strike/assault)
- Threaten military forces of potential enemies (especially their WMD capabilities)
- ↓ Deter nuclear attacks (Trident SSBNs)



Threats Impacting Navy-Marine Corps Missions/1

- Increased availability of long-range weapons against naval-maritime formations
 - Ballistic missiles with terminal guidance
 - High-speed, sea-skimming cruise missiles
 - EM Guns
- Proliferation of nuclear, chemical, biological weapons
- Proliferation of inexpensive delivery systems and weapons, including
 - Air (UAVs, mini-UAVs)
 - Surface (USVs)
 - Underwater (UUVs, mines, mini-submarines, SDVs)
 - Land mines, IEDs, and other low-tech systems
 - MANPADS, laser devices, and other high-tech systems



Threats Impacting Navy-Marine Corps Missions/2

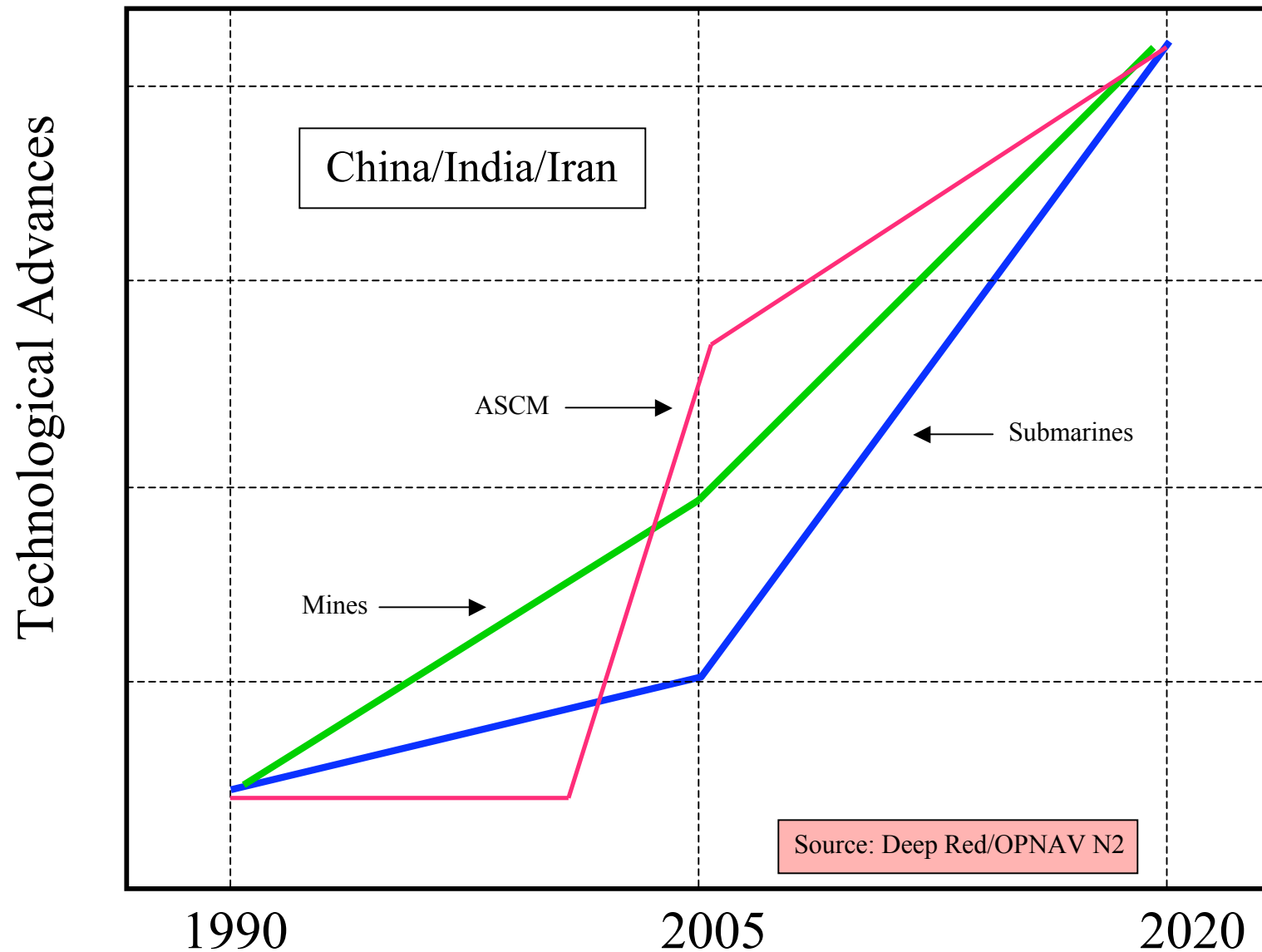
- Proliferation of advanced submarine technologies *and concepts of operation*
 - Propulsion
 - Sensors
 - Stealth
 - Weapons
- Proliferation of capabilities for sophisticated information warfare
- Increase in vulnerabilities of U.S. logistics
 - Pipeline
 - Overseas procurement of goods and services



Threats Impacting Navy-Marine Corps Missions/3

- Near-continuous surveillance of U.S. land and sea forces by opposing military and commercial satellites, “cheap” UAVs, and other means
- “Network centricity” creates vulnerabilities for U.S. forces
 - Interruption/jamming
 - Effective EMCON impossible
 - Information overload
 - Over-dependence on reachback
- Loss of low-observable effectiveness
- Reliance on GPS makes it a major target

Increasing Anti-Access Capabilities





Technology Traceability to Missions and Threats

| | | Threats Impacting Missions | Mission-Enabling Technologies |
|-----------------------------|---|---|---|
| Missions | Provide Seaborne Missile Defense Provide Seaborne Support for GWOT Protect Maritime Areas of Interest Project Military Power Threaten Adversary Military Forces Deter Nuclear Attacks | Advanced Submarines Continuous Surveillance by Potential Adversaries GPS as Common Point of Vulnerability Inexpensive Delivery Systems Information Warfare Proliferation Logistics Pipeline Vulnerability Loss of Low Observable Effectiveness LR Delivery Systems Networked Vulnerability WMD Proliferation | Advanced AAW Antenna Technology Coordinated, Multimode ASW Effective C2 in EMCON Environmental Sciences Lower-Cost Platforms Offensive Mine Warfare Pattern Recognition & Anomaly Detection Robust Offensive Information Warfare Upstream Information Fusion |
| Counter-Threat Technologies | Active Acoustic Systems Discrimination & Clutter Rejection False Target Generation & Deception Foreign S&T Awareness Formal Methods for VVA GPS Alternative GPS Deep-Fade Technology Information Assurance Overseas Supply Chain Surety | | Overarching Issues Formal mechanism for assessing U.S. vulnerabilities Fundamental understanding of COTS Long-term program to develop S&T workforce Improved coordination of R&D programs Requirements-linked, long-range planning process for S&T investment strategy Long-range S&T review |



Technology Traceability to Navy Marine-Corps Missions

| | |
|-----------------|--|
| Missions | Provide Seaborne Missile Defense Provide Seaborne Support for GWOT Protect Maritime Areas of Interest Project Military Power Threaten Adversary Military Forces Deter Nuclear Attacks |
|-----------------|--|



Technology Traceability to Missions Indexed by Threats

| | | Threats Impacting Missions | | | | | | | | | | |
|----------|------------------------------------|----------------------------|--|--------------------------------------|------------------------------|-----------------------------------|----------------------------------|--------------------------------------|---------------------|------------------------------|-------------------|---|
| Missions | Provide Seaborne Missile Defense | ● | ● | ● | ● | ● | | | ● | ● | | |
| | Provide Seaborne Support for GWOT | | ● | | ● | | | | | ● | ● | ● |
| | Protect Maritime Areas of Interest | ● | ● | | ● | ● | ● | | ● | ● | ● | ● |
| | Project Military Power | ● | ● | ● | ● | ● | ● | | ● | ● | ● | ● |
| | Threaten Adversary Military Forces | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● |
| | Deter Nuclear Attacks | | ● | | | | | | | | | |
| | | Advanced Submarines | Continuous Surveillance by Potential Adversaries | GPS as Common Point of Vulnerability | Inexpensive Delivery Systems | Information Warfare Proliferation | Logistics Pipeline Vulnerability | Loss of Low Observable Effectiveness | LR Delivery Systems | Net-centricity Vulnerability | WMD Proliferation | |



Technology Traceability to Counter-Threat Technologies

| | | Threats Impacting Missions | | | | | | | | | |
|-----------------------------|-------------------------------------|----------------------------|--|--------------------------------------|------------------------------|-----------------------------------|----------------------------------|--------------------------------------|---------------------|------------------------------|-------------------|
| | | Advanced Submarines | Continuous Surveillance by Potential Adversaries | GPS as Common Point of Vulnerability | Inexpensive Delivery Systems | Information Warfare Proliferation | Logistics Pipeline Vulnerability | Loss of Low Observable Effectiveness | LR Delivery Systems | Net-centricity Vulnerability | WMD Proliferation |
| Missions | Provide Seaborne Missile Defense | ● | ● | ● | ● | ● | | | ● | ● | |
| | Provide Seaborne Support for GWOT | | ● | | ● | | | | | ● | ● |
| | Protect Maritime Areas of Interest | ● | ● | | ● | ● | ● | ● | ● | ● | ● |
| | Project Military Power | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| | Threaten Adversary Military Forces | ● | ● | ● | ● | ● | | ● | ● | ● | ● |
| | Deter Nuclear Attacks | | ● | | | | | | | | |
| Counter-Threat Technologies | Active Acoustic Systems | ● | | | ● | | | | | | |
| | Discrimination & Clutter Rejection | ● | | | ● | | | | ● | | |
| | False Target Generation & Deception | | ● | | | | | ● | ● | | |
| | Foreign S&T Awareness | ● | ● | ● | ● | ● | | ● | ● | | ● |
| | Formal Methods for VVA | | | | | ● | | | | | |
| | GPS Alternative | | | ● | | | | | | | |
| | GPS Deep-Fade Technology | | | ● | | | | | | | |
| | Information Assurance | | | | | ● | | | | ● | |
| | Overseas Supply Chain Surety | | | | | | ● | | | | |



Technology Traceability to Mission-Enabling Technologies

| | | Threats Impacting Missions | | | | | | | | | | Mission-Enabling Technologies | | | | | | | | | |
|-----------------------------|---|----------------------------|--|--------------------------------------|------------------------------|-----------------------------------|----------------------------------|--------------------------------------|---------------------|------------------------------|-------------------|-------------------------------|--------------------|----------------------------|-----------------------|------------------------|----------------------|------------------------|---|--------------------------------------|-----------------------------|
| | | Advanced Submarines | Continuous Surveillance by Potential Adversaries | GPS as Common Point of Vulnerability | Inexpensive Delivery Systems | Information Warfare Proliferation | Logistics Pipeline Vulnerability | Loss of Low Observable Effectiveness | LR Delivery Systems | Net-centricity Vulnerability | WMD Proliferation | Advanced AAW | Antenna Technology | Coordinated, Multimode ASW | Effective C2 in EMCON | Environmental Sciences | Lower-Cost Platforms | Offensive Mine Warfare | Pattern Recognition & Anomaly Detection | Robust Offensive Information Warfare | Upstream Information Fusion |
| Missions | Provide Seaborne Missile Defense Provide Seaborne Support for GWOT Protect Maritime Areas of Interest Project Military Power Threaten Adversary Military Forces Deter Nuclear Attacks | ● | ● | ● | ● | ● | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| | | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Counter-Threat Technologies | Active Acoustic Systems Discrimination & Clutter Rejection False Target Generation & Deception Foreign S&T Awareness Formal Methods for VVA GPS Alternative GPS Deep-Fade Technology Information Assurance Overseas Supply Chain Surety | ● | | | ● | | | | ● | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| | | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |



Technology Traceability to Missions and Threats

| | | Threats Impacting Missions | | | | | | | | | | Mission-Enabling Technologies | | | | | | | | | |
|------------------------------|-------------------------------------|----------------------------|--|--------------------------------------|------------------------------|-----------------------------------|----------------------------------|--------------------------------------|---------------------|------------------------------|-------------------|--|--------------------|----------------------------|-----------------------|------------------------|----------------------|------------------------|---|--------------------------------------|-----------------------------|
| | | Advanced Submarines | Continuous Surveillance by Potential Adversaries | GPS as Common Point of Vulnerability | Inexpensive Delivery Systems | Information Warfare Proliferation | Logistics Pipeline Vulnerability | Loss of Low Observable Effectiveness | LR Delivery Systems | Net-centricity Vulnerability | WMD Proliferation | Advanced AAW | Antenna Technology | Coordinated, Multimode ASW | Effective C2 in EMCON | Environmental Sciences | Lower-Cost Platforms | Offensive Mine Warfare | Pattern Recognition & Anomaly Detection | Robust Offensive Information Warfare | Upstream Information Fusion |
| Missions | Provide Seaborne Missile Defense | ● | ● | ● | ● | ● | | | ● | ● | | ● | ● | ● | ● | ● | | | | | ● |
| | Provide Seaborne Support for GWOT | ● | ● | | ● | | | | | ● | ● | | ● | ● | | ● | ● | | ● | | ● |
| | Protect Maritime Areas of Interest | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| | Project Military Power | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| | Threaten Adversary Military Forces | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| | Deter Nuclear Attacks | | ● | | | | | | | | | | ● | ● | | ● | | | | | ● |
| Counter-Threat Technologies | Active Acoustic Systems | ● | | | ● | | | | | | | | | | | | | | | | |
| | Discrimination & Clutter Rejection | ● | | | ● | | | | ● | ● | | | | | | | | | | | |
| | False Target Generation & Deception | | ● | | | | | ● | ● | | | | | | | | | | | | |
| | Foreign S&T Awareness | ● | ● | ● | ● | ● | | ● | ● | | ● | | | | | | | | | | ● |
| | Formal Methods for VVA | | | | | ● | | | | | | | | | | | | | | | |
| | GPS Alternative | | | ● | | | | | | | | | | | | | | | | | |
| | GPS Deep-Fade Technology | | | ● | | | | | | | | | | | | | | | | | |
| | Information Assurance | | | | | ● | | | | ● | | | | | | | | | | | |
| Overseas Supply Chain Surety | | | | | | ● | | | | | | | | | | | | | | | |
| | | Overarching Issues | | | | | | | | | | Formal mechanism for assessing U.S. vulnerabilities Fundamental understanding of COTS Long-term program to develop S&T workforce Improved coordination of R&D programs Requirements-linked, long-range planning process for S&T investment strategy Long-range S&T review | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |



Findings/1

Counter-Threat Technologies Investments

- Tactical/Operational
 - Active acoustic systems
 - Discrimination and clutter rejection
 - False target generation for deception
 - GPS deep-fade technology
 - GPS alternative
- Logistics
 - Security for overseas supply chain
- Capabilities/Systems Development
 - Foreign S&T awareness
 - Formal, automated methods for Verification, Validation, and Accreditation
 - Information assurance



Findings/2

Mission-Enabling Technologies Investments

- Tactical/Operational
 - Advanced AAW
 - Coordinated, multimode ASW
 - Effective C² in EMCON
 - Offensive mine warfare
 - Pattern recognition and anomaly detection
 - Robust offensive information warfare
 - Upstream information fusion
- Capabilities/Systems development
 - Antenna technology
 - Environmental sciences (specific areas)
 - Low-cost platforms technologies



Findings/3

Overarching Issues Requirements

- Formal mechanism for assessing U.S. vulnerabilities
- Fundamental understanding of COTS
 - Business models
 - Technology drivers
 - Standards
 - Internal structure, functionality, vulnerabilities
- Long-term program to develop S&T workforce
- Improved coordination of R&D programs
- Requirements-linked, long-range planning process for S&T investment strategy
- NRAC long-range S&T review should be a continuing responsibility

Conclusion/1

The **bottom line** is that

While the Navy has a productive S&T program today....

The rapidly changing threat and the rate of world technological development demands change in the Navy-Marine Corps investment strategy for S&T over the next 15 years to insure that the naval services can continue to effectively carry out their missions.



Conclusion/2

Failure to change the investment strategy for Navy-Marine Corps S&T will make technological surprise on the battlefield **likely**...and success in executing naval missions will be **problematic**.



Recommendations/1

- **Develop Long-Term S&T Planning Process**

The ASN(RDA) should direct that his staff, the Chief of Naval Research, and appropriate OPNAV codes develop a long-term S&T planning process to help guide the future of Navy-Marine Corps S&T investment. Such a process should address (1) probable missions, (2) related systems capabilities, (3) related platform type requirements, and (4) related S&T requirements for required capabilities.

Further, it is proposed that the study sponsor, N6/7, recommend that this ongoing effort be made responsible to the Department of the Navy's S&T Corporate Board.*

***Note: The S&T Corporate Board consists of the Vice Chief of Naval Operations, the Assistant Commandant of the Marine Corps, and Assistant Secretary of the Navy (RDA), with the Chief of Naval Research as board secretary.**



Recommendations/2

- **Develop Long-Term S&T Workforce Plan**

The ASN(RDA) should determine the extent to which the NRAC report of 2002 has been implemented and remains valid with respect to the civilian S&T workforce, And, in collaboration with the Commander Naval Education and Training Command, the Chief of Naval Personnel, the appropriate Navy and Marine Corps systems commands, determine those actions to be recommended for retaining uniformed personnel in the S&T workforce.



Recommendations/3

- **Accelerate Lower-Cost Platform Technologies**

The ASN(RDA) should determine in conjunction with the Naval Sea Systems Command the means to initiate a comprehensive analysis based on the above cited concepts to review the above cited concepts for ships design and their implementation to date, and insure that they are adopted to the maximum extent practical in the "next" Navy ship design. In particular, the extended service lives of contemporary warships demands that high priority be given to transition to these concepts prior to initiation of the next major surface ship or submarine design.



Recommendations/4

- **Assess and Mitigate Long-Term COTS Vulnerabilities**

The ASN(RDA) should form a joint task force representing the Office of Naval Research and the appropriate systems commands that would be empowered to develop a business model for assessing the potential vulnerabilities of COTS insertion into naval systems. Such an assessment should address technology drivers, standards, internal structure, functionality, and supportability. Develop a program to enable mitigation of potential vulnerabilities.



Technology Traceability to Missions and Threats

| | | Threats Impacting Missions | | | | | | | | | | Mission-Enabling Technologies | | | | | | | | | |
|--|-------------------------------------|----------------------------|--|--------------------------------------|------------------------------|-----------------------------------|----------------------------------|--------------------------------------|---------------------|------------------------------|-------------------|-------------------------------|--------------------|----------------------------|-----------------------|------------------------|----------------------|------------------------|---|--------------------------------------|-----------------------------|
| | | Advanced Submarines | Continuous Surveillance by Potential Adversaries | GPS as Common Point of Vulnerability | Inexpensive Delivery Systems | Information Warfare Proliferation | Logistics Pipeline Vulnerability | Loss of Low Observable Effectiveness | LR Delivery Systems | Net-centricity Vulnerability | WMD Proliferation | Advanced AAW | Antenna Technology | Coordinated, Multimode ASW | Effective C2 in EMCON | Environmental Sciences | Lower-Cost Platforms | Offensive Mine Warfare | Pattern Recognition & Anomaly Detection | Robust Offensive Information Warfare | Upstream Information Fusion |
| Missions | Provide Seaborne Missile Defense | ● | ● | ● | ● | ● | | | ● | ● | | ● | ● | ● | ● | ● | | | | | ● |
| | Provide Seaborne Support for GWOT | | ● | | ● | | | | | ● | | | ● | | | | | | ● | | ● |
| | Protect Maritime Areas of Interest | ● | ● | | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| | Project Military Power | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| | Threaten Adversary Military Forces | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● |
| | Deter Nuclear Attacks | | ● | | | | | | | | | | | ● | ● | | ● | | | | |
| Counter-Threat Technologies | Active Acoustic Systems | ● | | | ● | | | | | | | ● | | | | | | | | | |
| | Discrimination & Clutter Rejection | ● | | | ● | | | | ● | | | | | | | | | | | | |
| | False Target Generation & Deception | | ● | | | | | ● | ● | | | | | | | | | | | | |
| | Foreign S&T Awareness | ● | ● | ● | ● | ● | | ● | ● | | ● | | | | | | | | | | |
| | Formal Methods for VVA | | | | | ● | | | | | | | | | | | | | | | |
| | GPS Alternative | | | ● | | | | | | | | | | | | | | | | | |
| | GPS Deep-Fade Technology | | | ● | | | | | | | | | | | | | | | | | |
| | Information Assurance | | | | | ● | | | | ● | | | | | | | | | | | |
| | Overseas Supply Chain Surety | | | | | | ● | | | | | | | | | | | | | | |
| Overarching Issues | | | | | | | | | | | | | | | | | | | | | |
| Formal mechanism for assessing U.S. vulnerabilities | | | | | | | | | | | | | | | | | | | | | |
| Fundamental understanding of COTS | | | | | | | | | | | | | | | | | | | | | |
| Long-term program to develop S&T workforce | | | | | | | | | | | | | | | | | | | | | |
| Improved coordination of R&D programs | | | | | | | | | | | | | | | | | | | | | |
| Requirements-linked, long-range planning process for S&T investment strategy | | | | | | | | | | | | | | | | | | | | | |
| Long-range S&T review | | | | | | | | | | | | | | | | | | | | | |